Cost-effective OBC feasibility studies along with valuable high-resolution VSP data.

Grunde Ronholt, William Chmela, READ Well Services, Houston, Tx, USA

Abstract

Cost effective OBC Feasibility studies can be performed concurrently with the acquisition of walkaway VSPs (2D or 3D). READ Well Services (RWS) now offers deployment of four-component ocean bottom cables (OBC) as an addition to standard 2D or 3D VSP surveys.

The recording is done from a separate vessel or using a remotely operated buoy. The objective is to acquire OBC data simultaneously with the VSP acquisition using the same source vessel and source points.

Whereas the VSP yields a high resolution P-P and P-S image over a restricted area, the OBC will yield a slightly lower resolution image with a greater coverage area. Due to the fact that the down-going wavefield is recorded in the VSP, parameters such as direct P-velocity, transmitted S-velocity, Q-values and anisotropy can be estimated with great accuracy. These parameters can be applied to greatly improve the quality of the OBC image. The OBC data from the combined OBC/VSP survey can be used as feasibility study to deternine if a larger scale OBC survey might be conducted over the field.

The advantage of acquiring OBC data simultaneously with VSP is in the economics. The seismic crew, seismic source vessel and recording unit have already been deployed offshore for the VSP. There is often waiting time associated with the drilling rig when the 3DVSP crew is not productive. The additional cost for laying a couple of OBC lines and acquiring more data is small compared to mobilizing a complete OBC crew for a separate feasibility study.

A simple offshore velocity model has been designed in order to create synthetic data to illustrate the combined VSP/OBC imaging technique .

Introduction

Walkaway VSPs (2D or 3D) have traditionally been acquired to yield a high-resolution image of the reservoir zone. As technology improves and longer arrays with more geophones are deployed into the borehole the technique has been greatly improved. With the extended array wavefield separation improves, the migrated image has a higher signal to noise ratio, the coverage of dipping reflectors will improve and most importantly rig time will be significantly reduced. Longer arrays also allow the anisotropy calculations, local and average, to be determined over a larger portion of the geological section.

RWS currently offers up to a 32-level array (96 channels) running on standard 7 conductor wire-line. With the array anchored such that the bottom geophone is located immediately above the target reflector, velocity and anisotropy parameters to the reflector can be determined and still yield a 'normal' VSP image from the top geophones.

The 4C data from the 40 node OBC data can be processed in a similar manner as the VSP, with separation of up- and down-going wavefields. This separation allows for the utilization of the favored deterministic instead of predictive deconvolution (Amundsen et al. 2001). Performing these processing steps in the tau,p domain makes it valid for all offsets. P- and S-velocities taken from the VSP, yields detailed information difficult to pull out of the OBC data. Anisotropy parameters estimated from the VSP are also applied in the OBC pre-stack depth migration, greatly improving the accuracy of the final OBC image.

Velocity Model

A simple velocity model (Figure 1) has been built in NORSAR2D in order to create synthetic data to illustrate the technique. The model was built with a water column of 1500 m and a dipping target reflector at ~2200 m depth below MSL. The trap is a wedge with gas over oil over water.

Synthetic Data

VSP data was created comprising 24 receivers and 401 shots. Shot spacing was 25 meters and receiver spacing 30 meters. Receiver depths are from 2390 to 1700 meters below MSL (Figure 2).

OBC data was created comprising 40 receivers and 401 shots. Shot spacing was 25 meters and receiver spacing 50 meters (Figure 3). Receiver depths are 1500 meters (sea floor).

Multi-component Processing

In VSP and OBC data the 3C geophones acquire vector up- and down-going wavefields. Through elastic wavefield decomposition and deterministic deconvolution in the tau,p domain RWS is able to extract multiple-free up-going scalar P-P and P-S wavefields (Amundsen and Reitan, 1995). These up-going primaries are input to anisotropic P-P/P-S depth migration for accurate and focused imaging.

Anisotropy

Seismic anisotropy effects are often described using Thomsen's parameters epsilon and delta. The down-going energy in a walkaway VSP describes these parameters down to a single receiver well by scanning a large range of angles in a 2D plane (Figures 4 & 5). By comparing the observed and modeled travel times for a range of source-receiver offsets a good estimate of how much the velocity increases with a higher propagation angle is determined

Amplitude versus Offset

By placing a 3C geophone at ~100-150 m above a target reflector , a large number of angles can be scanned which are reflected from virtually the same point (Figures 6 & 7). We also record the downgoing arrival immediately before the reflection at each of these angles. With careful processing of this data the amplitude versus offset and/or angle profile can be generated and compared to any AVO-model.

Migration

The scalar primaries (P-P and P-S) can be depth migrated with greater accuracy when using more correct P- and S-velocities along with anisotropy parameters epsilon and delta. Figures 8 and 9 show the depth migration results from the synthetic OBC data.

Conclusions

Deploying an OBC system along with the acquisition of an offset VSP survey clearly adds valuable information for the seismic interpreter. A greater aperture P-P and P-S image complements the high-resolution VSP image.

Along with the images, valuable velocity, anisotropy and AVO information can be gained.

Acknowledgments

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References

Amundsen, L. and Reitan, A., 1995, Decomposition of multicomponent sea-floor data into upgoing and downgoing P- and S-waves: GEOPHYSICS, Soc. of Expl. Geophys., **60,** 563-572.

Amundsen, L., Ikelle, L. T. and Berg, L. E., 2001, Multidimensional signature deconvolution and free-surface multiple elimination of marine multicomponent ocean-bottom seismic data: GEOPHYSICS, Soc. of Expl. Geophys., **66,** 1594-1604.

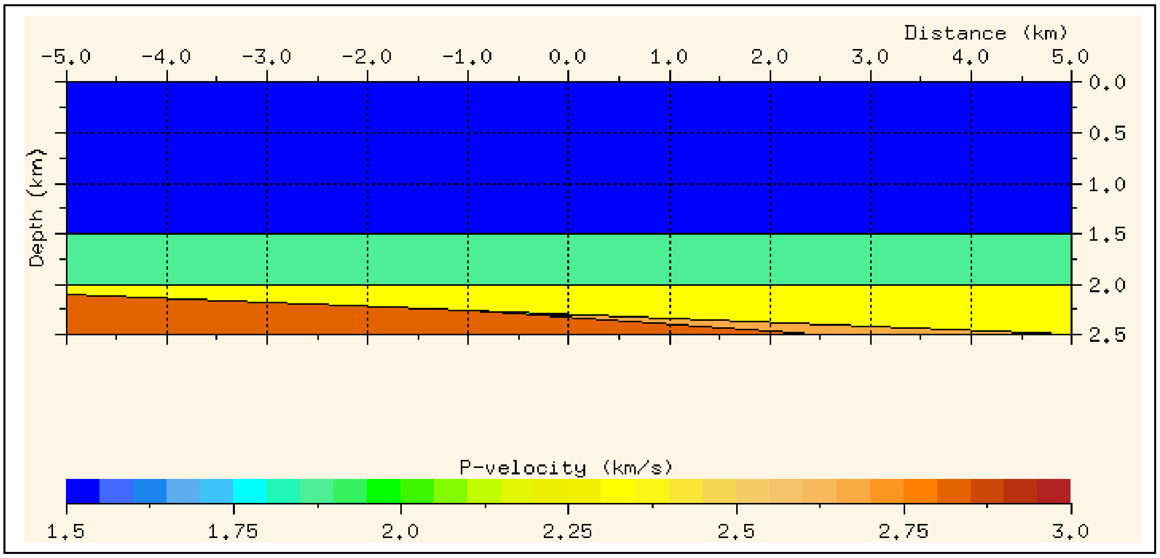

Figure 1: P-velocity model in deep water (1500 m) with shallow target (~2200 m). Well at co-ordinate = 0

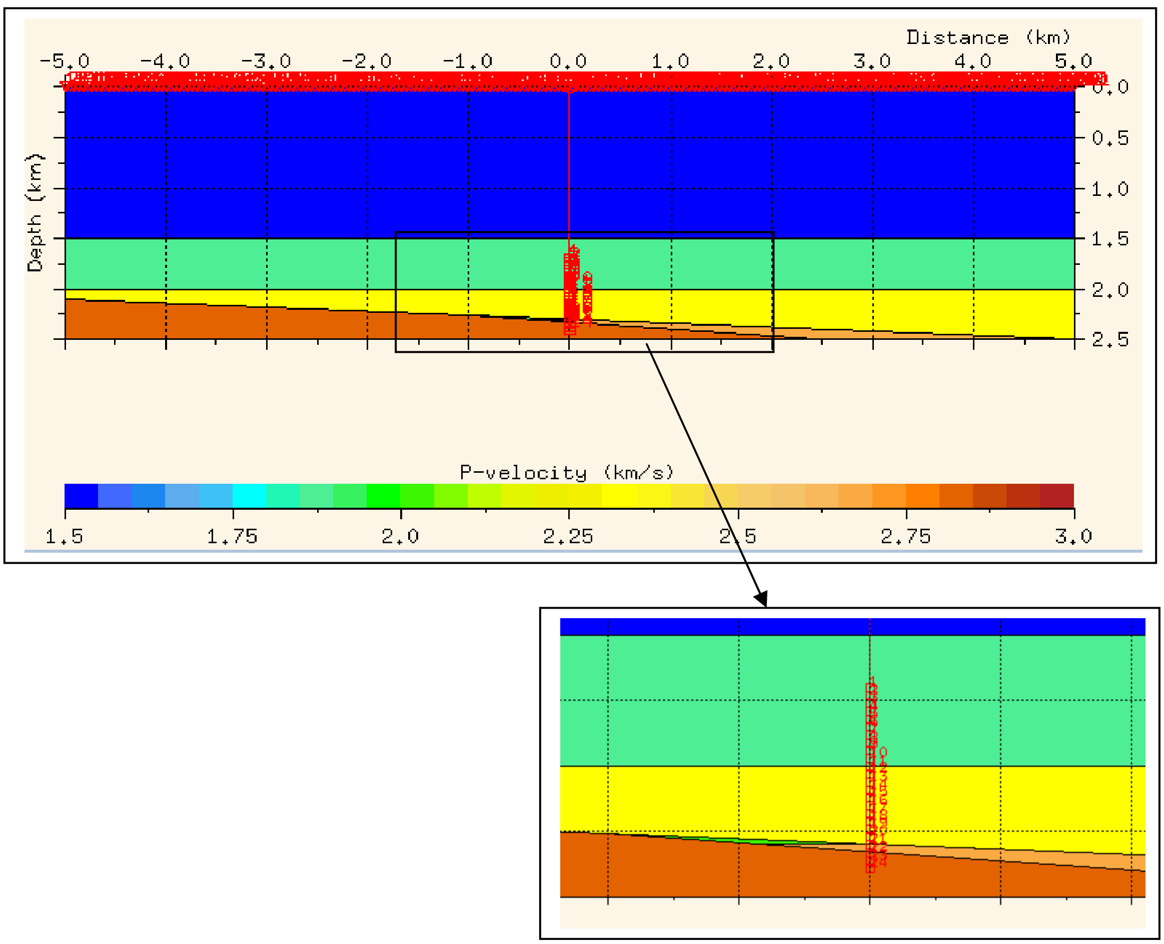

Figure 2: VSP survey, 24 receivers with 30 m spacing and 401 shots with 25 m spacing.

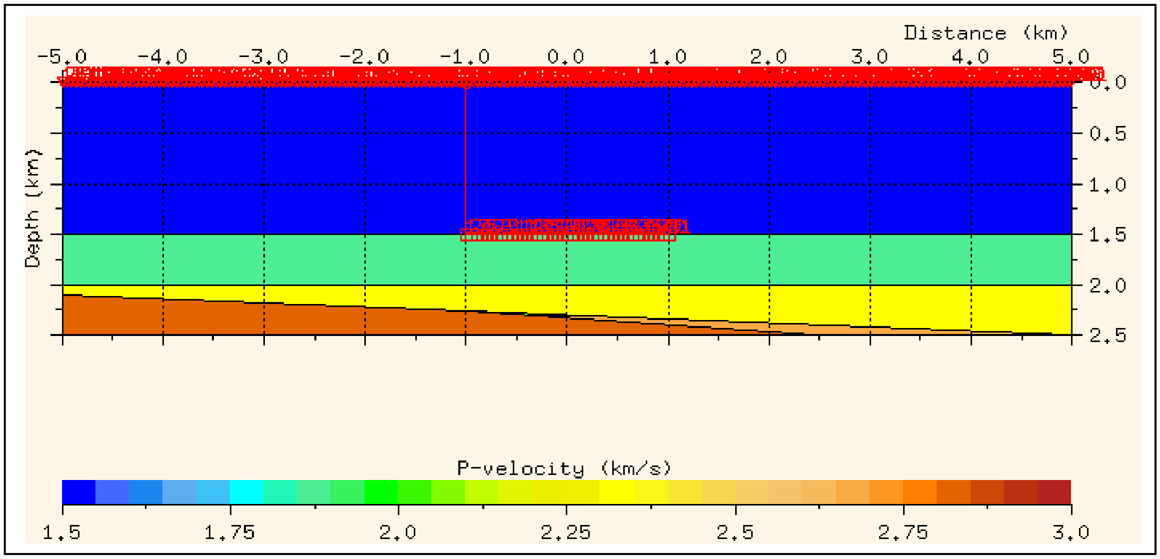

Figure 3: OBC survey, 24 receivers with 50 m spacing and 401 shots with 25 m spacing.

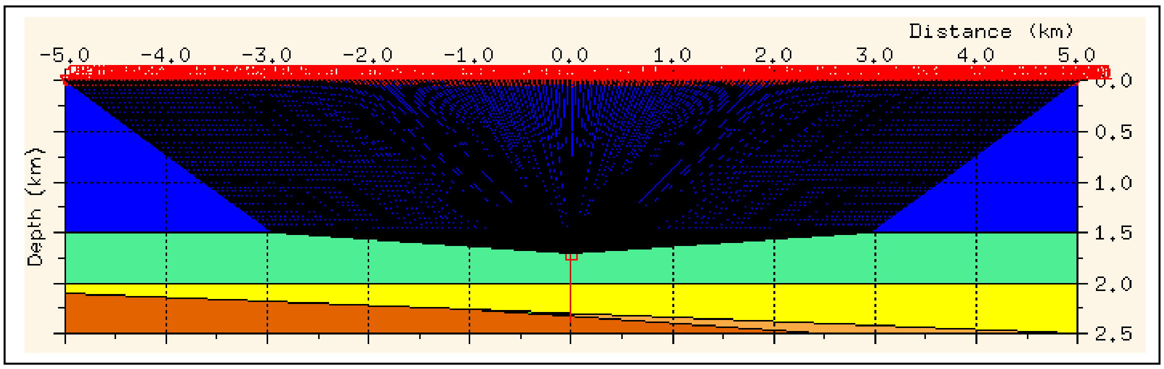

Figure 4: Direct arrival from top VSP receiver.

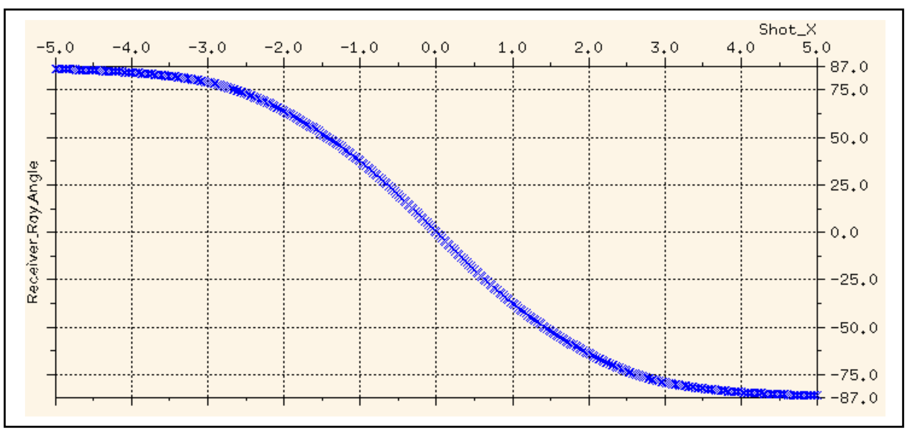

Figure 5: Direct arrival angle versus shot X for data in figure 4

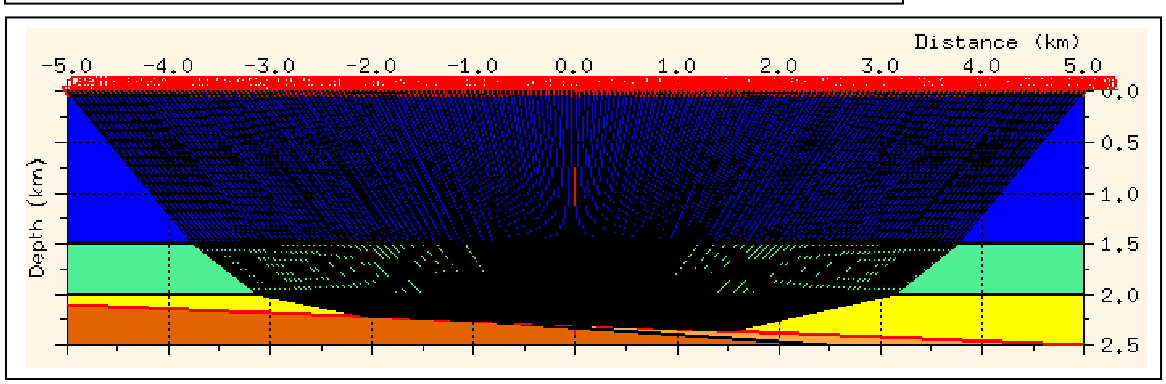

Figure 6: P reflected to P for the top reservoir reflector

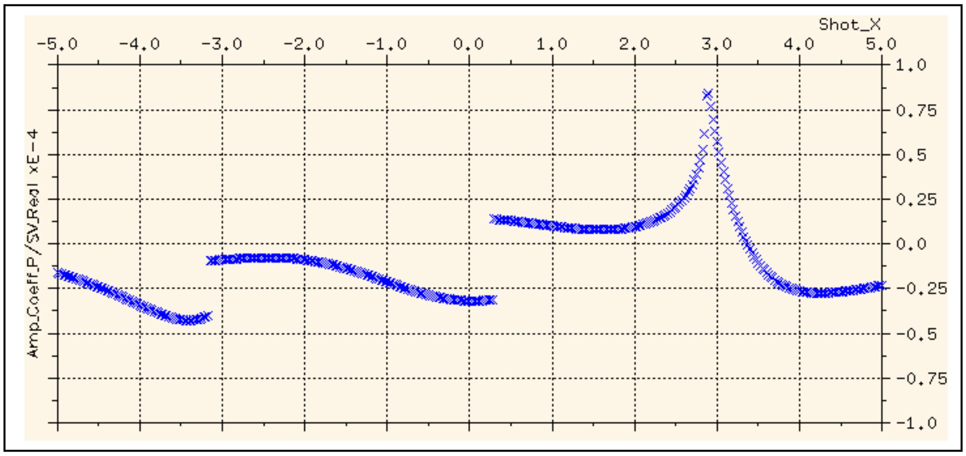

Figure 7:
Amplitude versus offset plot for data in figure 6.

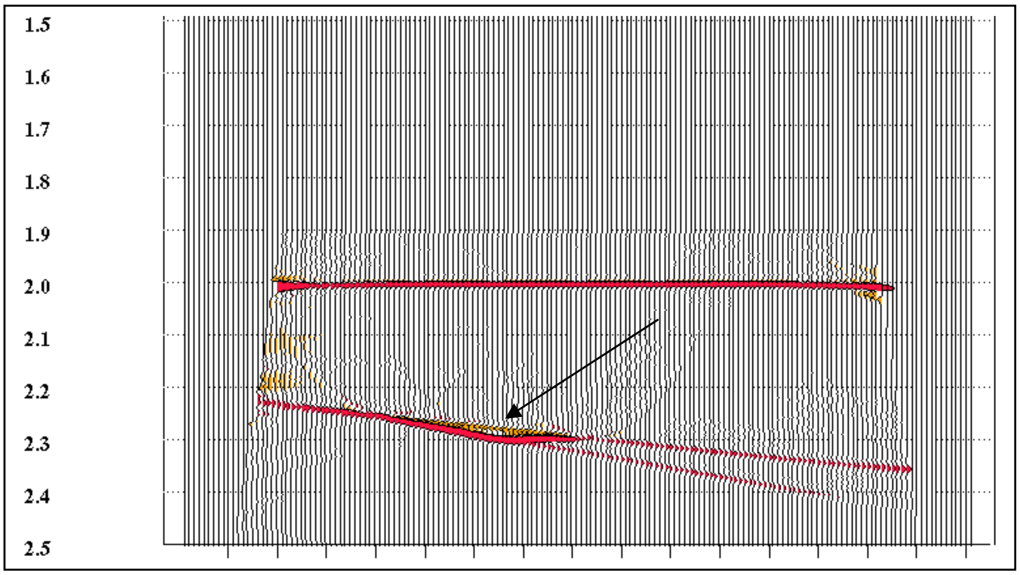

Figure 8:
OBC P-P depth migration CDP-stack. The polarity reversal on the top reservoir is indicated with an arrow

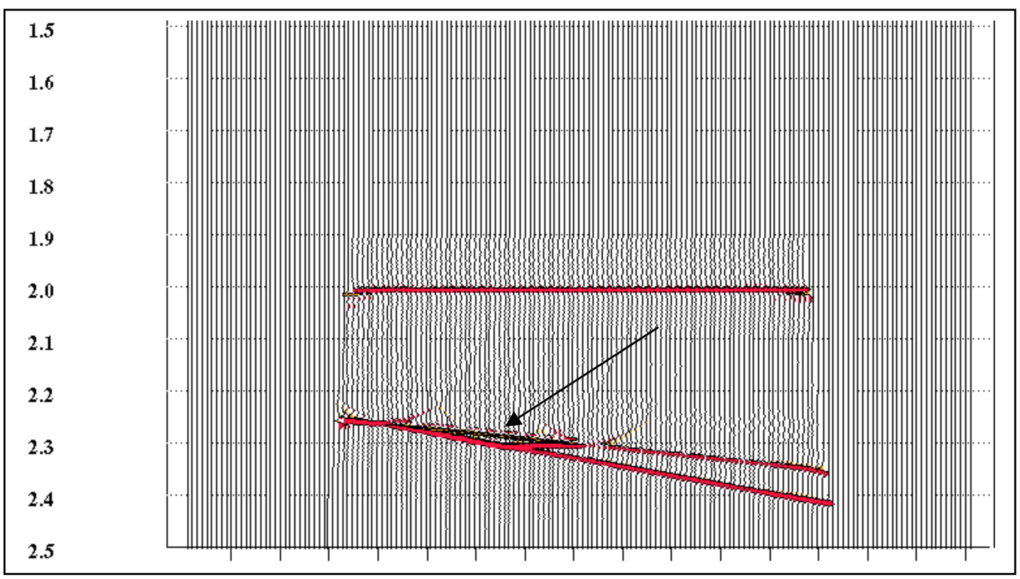

Figure 9:
OBC P-S depth migration CDP-stack. The polarity reversal on the top reservoir is indicated with an arrow